ELECTRONIC FUNDAMENTALS

SERVICE PRACTICES 18

CIRCUIT TRACING

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18-2. Wiring Diagrams

18-3. Schematic Diagrams

18-4. Circuit Tracing

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RCA INSTITUTES, INC.

A SERVICE OF RADIO CORPORATION OF AMERICA

HOME STUDY SCHOOL

350 West 4th Street, New York 14, N. Y.

Service Practices 18

INTRODUCTION

Circuit tracing deals with identifying and following electric circuits and testing them for continuity. Continuity testing is discussed later in the lesson.

Servicemen use three types of drawings as an aid in circuit tracing. They are:

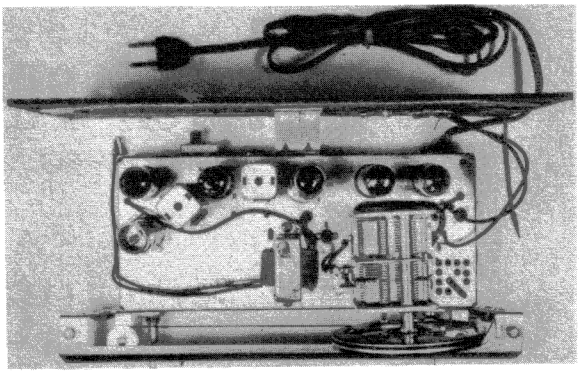
1. Layout diagrams
2. Wiring diagrams
3. Schematic diagrams

18-1 LAYOUT DIAGRAMS

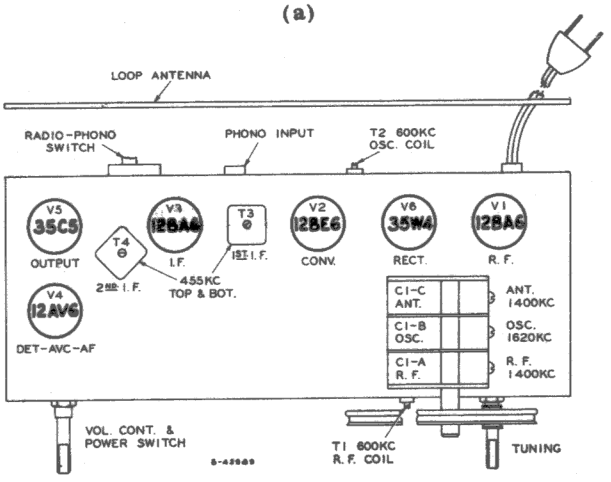
Layout diagrams are included in service data. We use them together with wiring and schematic diagrams (also a part of service data) to trace circuits. They are especially useful for finding out the type of tube that belongs in each socket. For this reason, layout diagrams are found pasted in radio cabinets as well as in service data.

Figure 18-1*a* is a photograph of a typical home-type radio receiver. Figure 18-1*b* is a layout diagram of the same view of the radio. A layout diagram is a simple drawing of *one* view of a radio chassis. It shows the location of large parts and tubes, the type of tube in each socket, the purpose of each tube, and the location of adjustments. Only one layout diagram is needed for the radio because the large parts can be seen in a drawing of the top view of the chassis.

Sometimes more than one layout diagram is needed to show all the large parts of a radio (Fig. 18-2). The portable is pictured in its case in Fig. 18-2*a*. The chassis is made with an irregular shape so that it will fit the small case. One view is not enough to show all the large parts. The parts pictured in Fig. 18-2*b* are shown in the layout diagram in Fig. 18-2*c*, and the parts in Fig. 18-2*d*



(a)



(b)

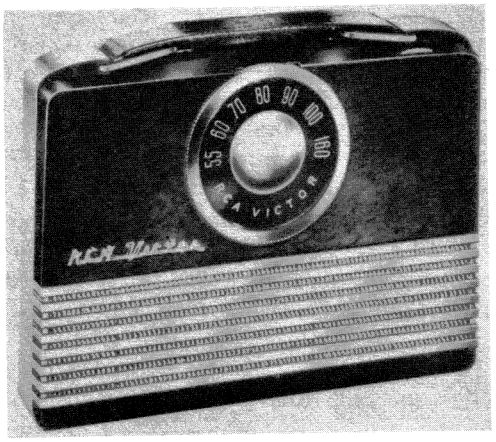
Fig. 18-1

appear in the diagram in Fig. 18-2*e*. Figure 18-2*f* shows the layout diagrams pasted in the portable case shown in Fig. 18-2*a*.

18-2. WIRING DIAGRAMS

A wiring diagram is a detailed drawing of the underside of a chassis. Like layouts, wiring diagrams show where parts are located. Unlike layouts, wiring diagrams show *all* parts, the small ones as well as the large ones. Another thing wiring diagrams show is how parts are wired together. The location of the wires is shown, and how the parts are electrically connected can also be seen.

A wiring diagram of the portable radio shown in Fig. 18-2 and 18-3*a* is shown in Fig. 18-3*b*. If the diagram were drawn exactly as we see the underside of the chassis, some parts would be hidden by others and the connecting wires would be hard to follow. We would not know what parts were connected together. Steps are taken to avoid such difficulties when a wiring diagram is drawn. For example, a capacitor is shown by



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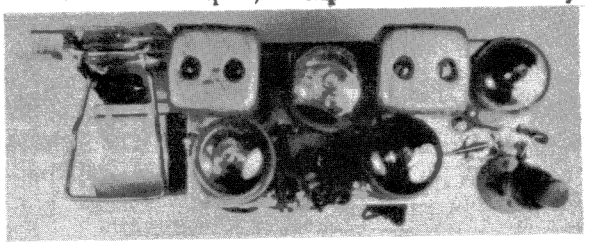

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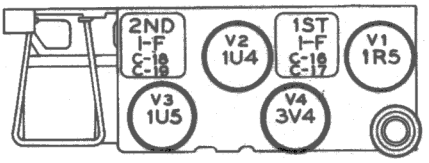

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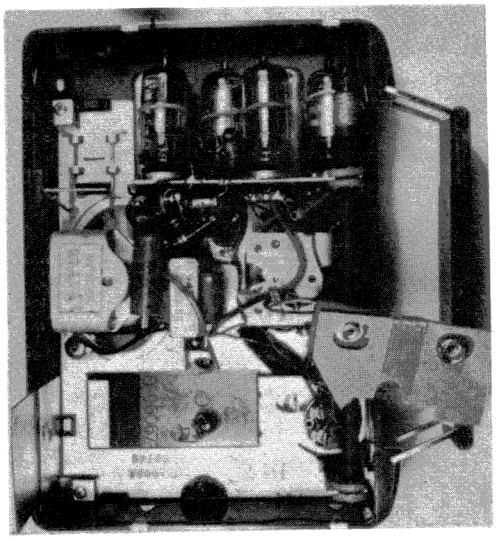

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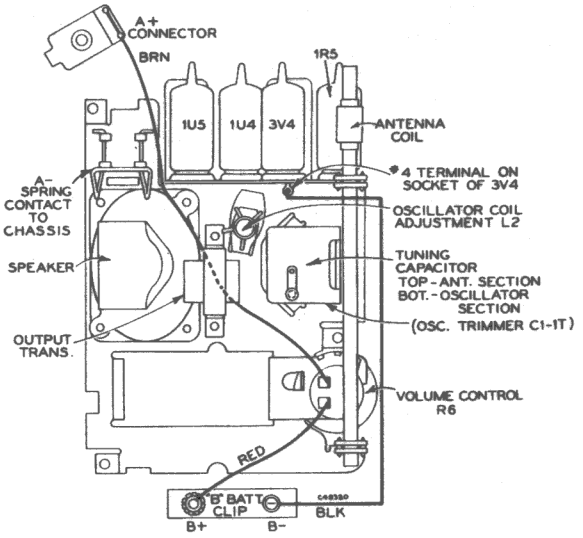


(e)

(f)

Fig. 18-2

a small box drawn like C_7 of Fig. 18-3*b*. If the capacitor is larger, the box is drawn larger, like C_{15}. Boxes are used to represent resistors too, but these are marked R for resistor instead of C for capacitor. Although parts on the wiring diagram do not look exactly like the real ones shown in Fig. 18-3*a*, we can understand the wiring diagram of Fig. 18-3*b* by checking it with the photo of Fig. 18-3*a*. While circuit tracing, we check the wiring diagram with the chassis wiring.

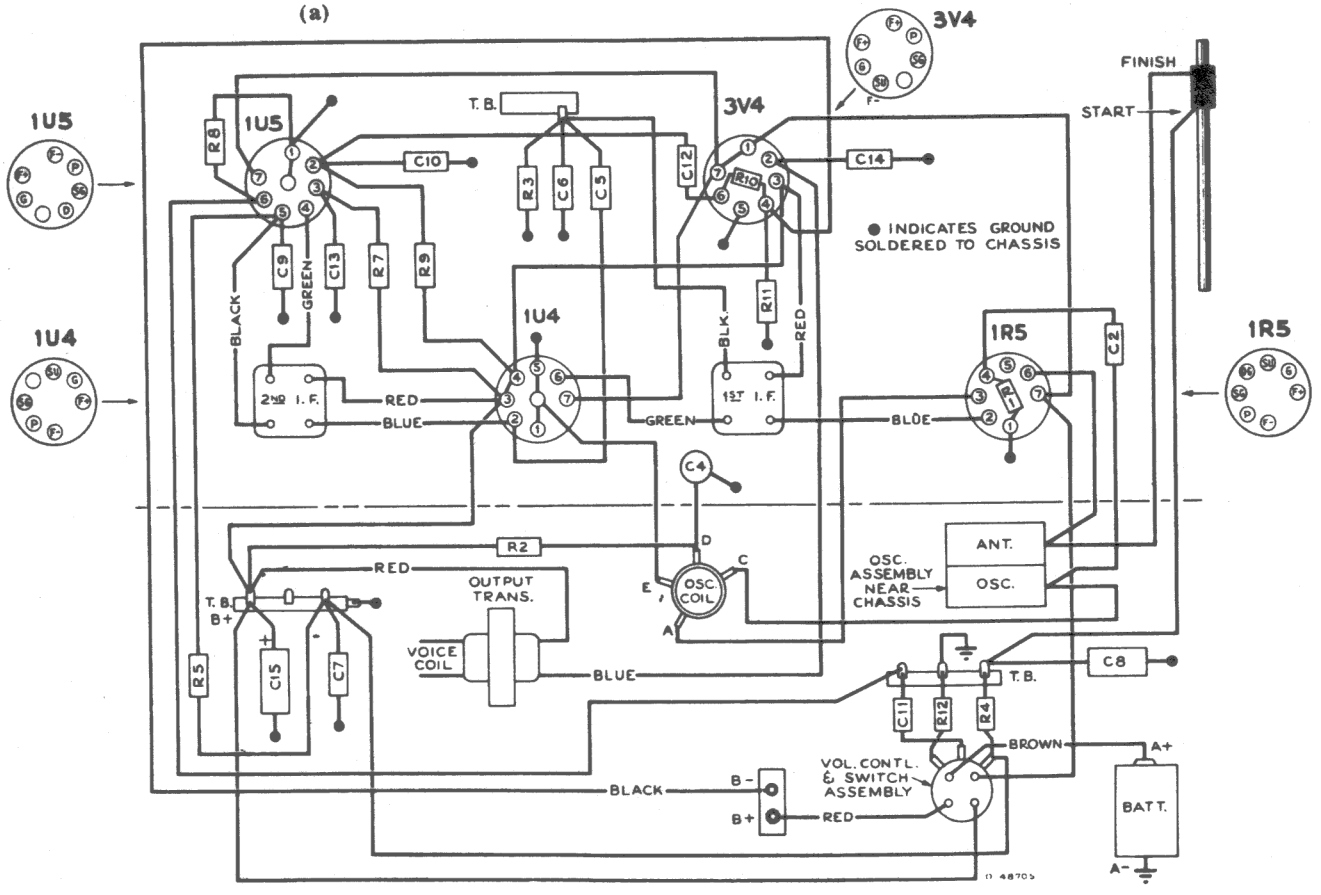
Let us see how the wiring diagram can be used. Suppose we are circuit tracing the receiver of Fig. 18-2 and 18-3 and we see a burned resistor. We want to know the value of the resistor in order to replace it. We see that it is connected to a coil near a large transformer. A small capacitor shaped like a circle is connected to the same terminal of the coil. The other lead from the capacitor is connected to chassis. With this information in mind, we go to the wiring diagram. We see that the large transformer is the OUTPUT TRANSFORMER. The coil near it is the OSC. COIL. The capacitor shaped like a circle is C_4. The resistor we want must be connected to the same terminal of the coil as C_4. So our resistor must be R_2.

The parts list (Fig. 18-4) shows R_2 to be 15,000 ohms ± 10%, 1/2 watt.

18-3. SCHEMATIC DIAGRAMS

If you have all the wiring diagrams for a receiver, you might be able to understand how the radio works. But it's much easier to

(a)



(b)

Fig. 18-3

Replacement Parts

STOCK No.	DESCRIPTION
	CHASSIS ASSEMBLIES RC 1098, RC 1098A
75778	Antenna—Ferrite rod antenna (L1)
75783	Capacitor—Variable tuning capacitor (C1-1, C1-2)
73153	Capacitor—Ceramic, 4 mmf. (C5)
75784	Capacitor—Ceramic, 56 mmf. (C2, C7)
75785	Capacitor—Ceramic, 82 mmf. (C9, C10)
73960	Capacitor—Ceramic, 10,000 mmf. (C4)
73964	Capacitor—Electrolytic, 10 mfd., 70 volts (C15)
72792	Capacitor—Tubular, paper, .001 mfd., 200 volts (C12)
72315	Capacitor—Tubular, paper, .002 mfd., 200 volts (C11, C14)
73961	Capacitor—Tubular, paper, .003 mfd., 200 volts (C6)
71928	Capacitor—Tubular, paper, .02 mfd., 200 volts (C13)
73553	Capacitor—Tubular, paper, .05 mfd., 400 volts (C8)
75781	Clip—"A" Battery mounting clip (negative)
75010	Clip—Output transformer mounting screw clip
75774	Coil—Oscillator coil complete with adjustable core (L2, L3)
75782	Contact—"A" Battery contact (positive)
75773	Control—Volume control and power switch (R6, S1)
37396	Grommet—Rubber grommet for antenna rod
75779	Knob—Volume control knob—less set screw (early type—does not have "ON" indication)
76321	Knob—Volume control knob—less set screw (late type—has "ON" indication)
75786	Lead—"B" battery lead complete with connector
76372	Plate—Four element "Printed Circuit" plate stamped 942660-1 (diode filter unit C7, C9, R4, R5)
76371	Plate—Six element "Printed Circuit" plate stamped 942659-1 (audio coupling unit C10, C12, R2, R7, R9, R10)
	Resistor—Fixed, composition:—
	390 ohms, ±10%, ½ watt (R11)
	1000 ohms, ±20%, ½ watt (R12)
	15,000 ohms, ±10%, ½ watt (R2)
	47,000 ohms, ±20%, ½ watt (R5)
	100,000 ohms, ±20%, ½ watt (R1)
	1 megohm, ±20%, ½ watt (R9)
	3.3 megohm, ±20%, ½ watt (R4, R10)
	4.7 megohm, ±20%, ½ watt (R3, R7)
	10 megohm, ±20%, ½ watt (R8)
70527	Screw—#6-32 x 3/16" socket head set screw for volume control knob
75780	Socket—Tube socket, 7 pin, miniature
75775	Transformer—First I-F transformer (T1)
75776	Transformer—Second I-F transformer (T2)
75777	Transformer—Output transformer (T3)
	SPEAKER ASSEMBLY 92523-4
76373	Speaker—2" x 3" P.M. speaker complete with cone and voice coil
	MISCELLANEOUS
75787	Back—Case back
75647	Case—Case assembly (front and back) complete with metal side trim, metal grille and emblem—less handle and links (early type—does not have "ON" indication opening)
76320	Case—Case assembly (front and back) complete with metal side trim, metal grille and emblem—less handle and links (late type has "ON" indication opening)
75651	Emblem—"RCA Victor" emblem
75648	Grille—Metal grille
75649	Handle—Carrying handle
75788	Knob—Dial knob less spring clip
75650	Link—Carrying handle link
75801	Screen—Crinoline screen (black) for case front
74734	Spring—Spring clip for dial knob

Fig. 18-4

understand a circuit when all the parts and connections are shown on a single drawing. A schematic diagram gives the *over-all picture* of how a radio works and in addition *shows details* of how each circuit within the receiver works. Schematic diagrams tell an experienced serviceman how the designers make a receiver perform each function. A block diagram is a simple means of giving the over-all picture of how a radio works without showing all the details. A block diagram of a radio is illustrated in Fig. 18-5*a*. It shows that the signal enters at the antenna, goes to the converter, to the i-f stages, to the audio-detector, to the output, and finally to the speaker. It does not tell us how each block works. We must go to the schematic to learn what fills each block of the block diagram. Fig. 18-5*b* and *c* show two different circuits that designers can use to fill the output block of Fig. 18-5*a*.

For circuit tracing purposes, a schematic diagram show two things:

1. It shows how parts are electrically connected together (but not where the connections are on the chassis). In this respect, it duplicates some information given on a wiring diagram.

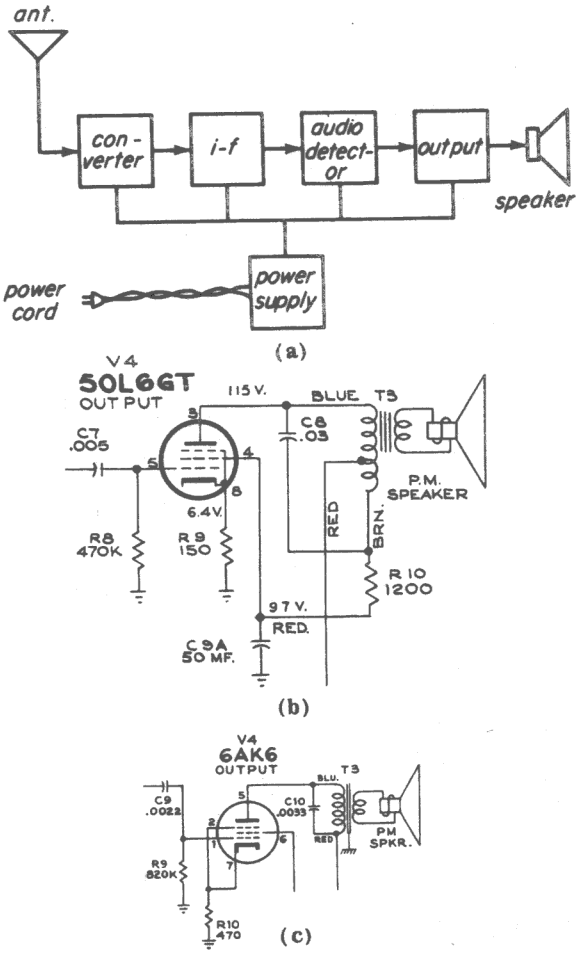


Fig. 18-5

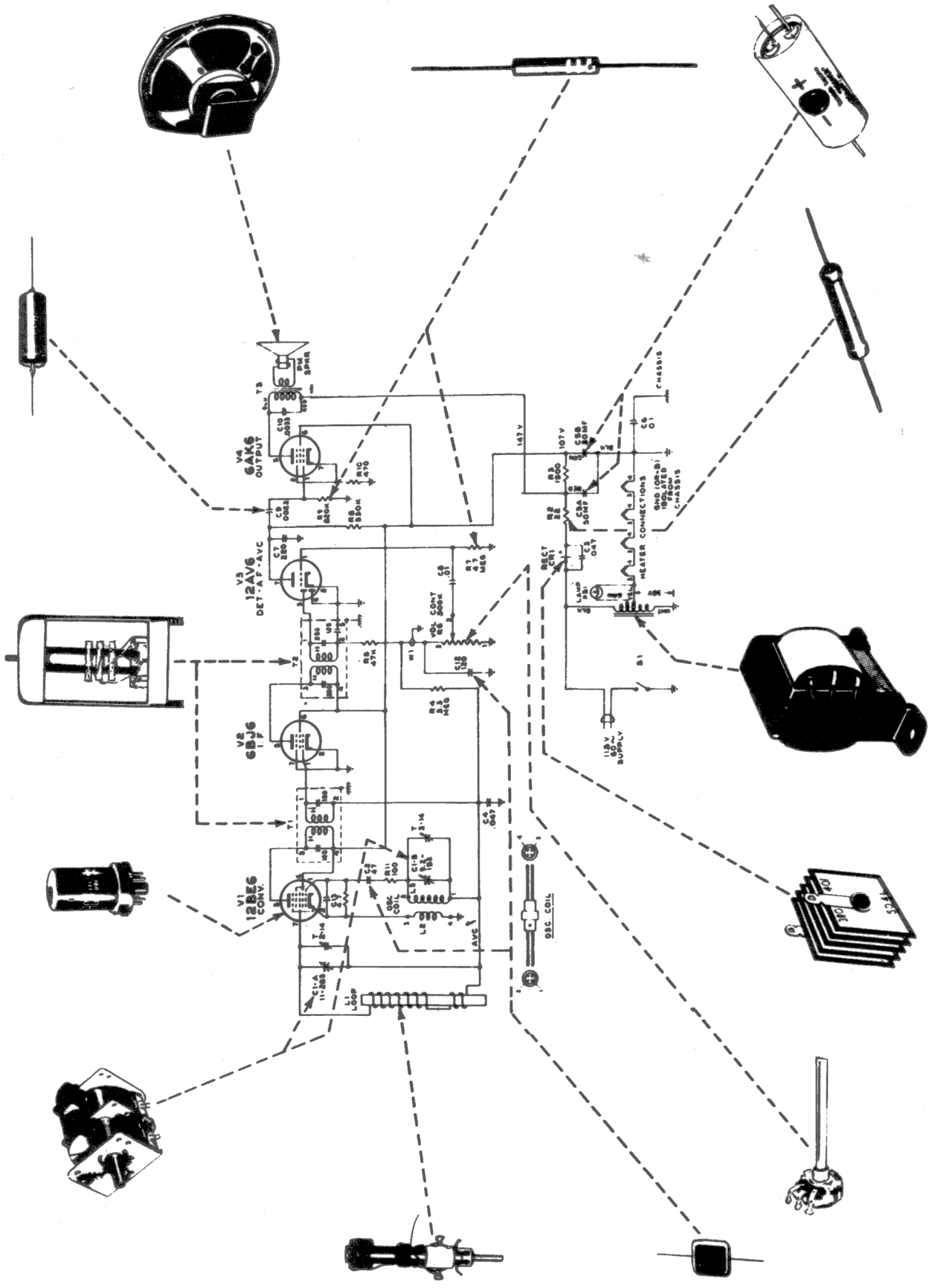

V4
6AK6
OUTPUT
V3
12AV6
DET-AF-AVC
V2
6BJ6
I-F
V1
12BE6
CONV.
OSC COIL
AVC
CONT
VOL
HEATER CONNECTIONS
CHASSIS
117 V
107 V
SEC. COIL

Fig. 18-6

2. It shows the electrical position (function) of parts in a circuit and their electrical values. Referring to our example of the use of a wiring diagram, we would not have to consult a parts list to learn the value of the burned resistor, once we had located it on a schematic diagram. The values of parts are usually shown on schematics.

For circuit-tracing purposes, it is not necessary to understand everything a schematic diagram tells us about how a circuit works. It *is* necessary to be able to *read* the *schematic* diagram so we can make use of what it tells us about how a circuit is connected together. Learning the alphabet of schematic diagrams is the first step towards learning to read the diagrams. You studied symbols – the alphabet of schematics – in Theory Lesson 2. You may want to refer to the symbols described in Lesson 2 while you are studying this booklet. The next step toward learning to read schematics is learning to associate a symbol with the actual part it represents. You studied the relationship between symbols and parts in various Service Practices booklets.

In circuit tracing, you should be able to look at a symbol but see a real radio part. Fig. 18-6 shows a schematic of a radio with pictures of the real parts that the symbols represent. If you know these relationships, it is possible to circuit-trace using a schematic without a wiring diagram.

Sometimes we want to know a little more about the relationship between parts and symbols. Referring to Fig. 18-7, for example we might want to know which way the center arm of the volume control would move if you turned the actual control shaft from left to right (clockwise). Note that the movement of

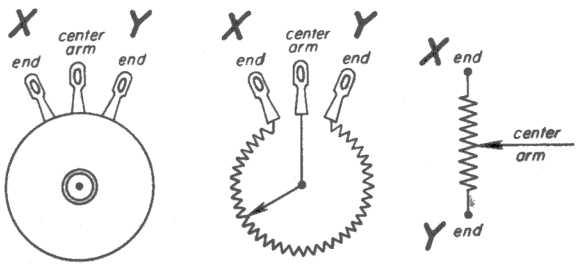


Fig. 18-7

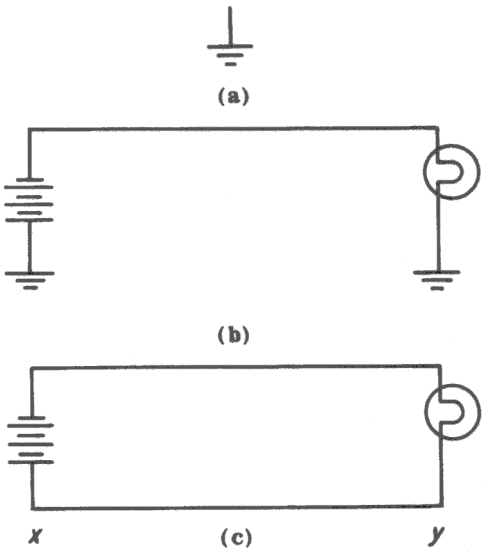


Fig. 18-8

the symbol arm would be from *Y* to *X*, not from *X* to *Y*.

The final step toward learning to read schematics is learning the rules about how the symbols should be connected together. These rules are called conventions and include such things as how to show a connection between wires and how to show wires crossing without a connection. Theory Lesson 2 deals with these conventions. One of the more important conventions concerns the use of the ground symbol. Let's consider the meaning of ground.

Fig. 18-8*a* is a ground symbol. When we see it on a schematic, we assume that it means a connection to chassis. Fig. 18-8*b* shows a battery grounded to chassis and a lamp also grounded to chassis. Since the other ends of the battery and lamp are connected, we know that the lamp will light. The ground end of the circuit is completed through the chassis, providing a way for current from the battery to flow through the lamp. The circuit could be drawn as shown in Fig. 18-8*c*. The two ground symbols in *b* tell us there is an electrical connection between *X* and *Y*, as shown in Fig. 18-8*c*. So, in addition to showing a connection to chassis, the ground symbol can show how one side of an electrical circuit is completed. Of course, electrical circuits always have to be completed. That is, there must be a path for current to flow back to the source of voltage.

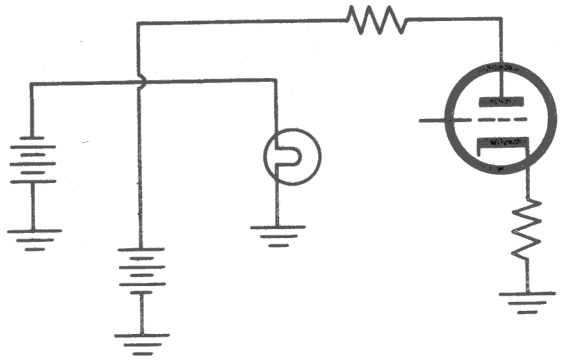


Fig. 18-9

In Fig. 18-9 the lamp circuit has become more complex. A second battery operating an electron tube has been added. Note that one side of the new electron-tube circuit is also shown by means of a ground symbol. Two or more separate circuits can be completed through the same chassis.

When you examine a schematic diagram for circuit tracing, decide to which circuits the ground symbols belong. Many radio schematics represent several complete electrical circuits.

The use of the ground symbol on a.c.-d.c. radio schematic diagrams can be somewhat confusing. Many such sets do not have the circuit completed through the chassis. Instead, direct wire connections are used for the entire circuit. This is done to eliminate the shock hazard of having the 115-volt power-line voltage on the chassis. As you have already learned, all connections that would go to chassis in an a-c set go to a common wire in a.c.–d.c. sets. The schematic of Fig. 18-10 represents an a.c.–d.c. receiver of the type we are discussing. The common wire is shown as a heavy line labeled B MINUS. This way of drawing the schematic diagram is not confusing. The ground symbol means connection to chassis. For example, at the lower right-hand part of

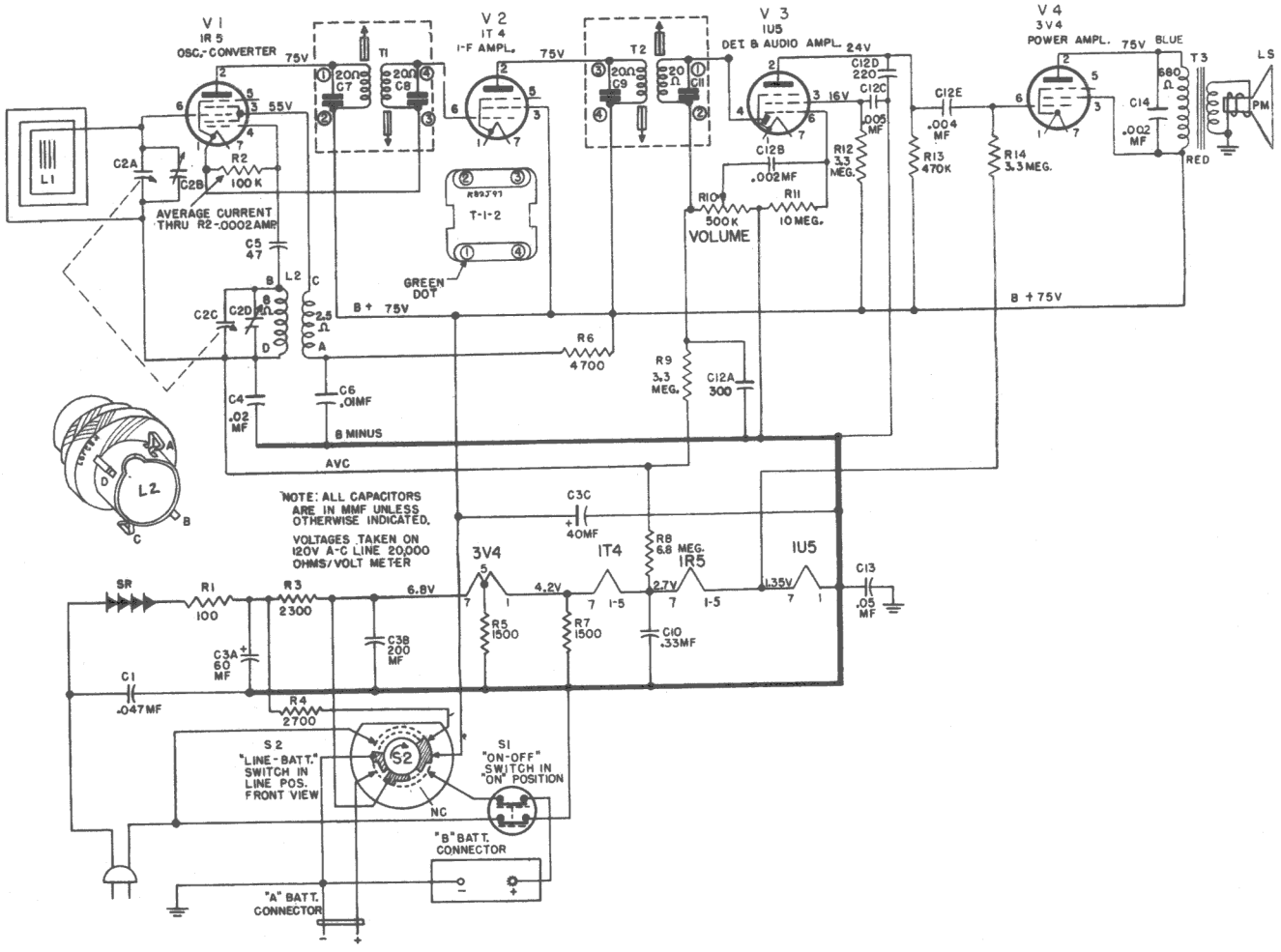


Fig. 18-10

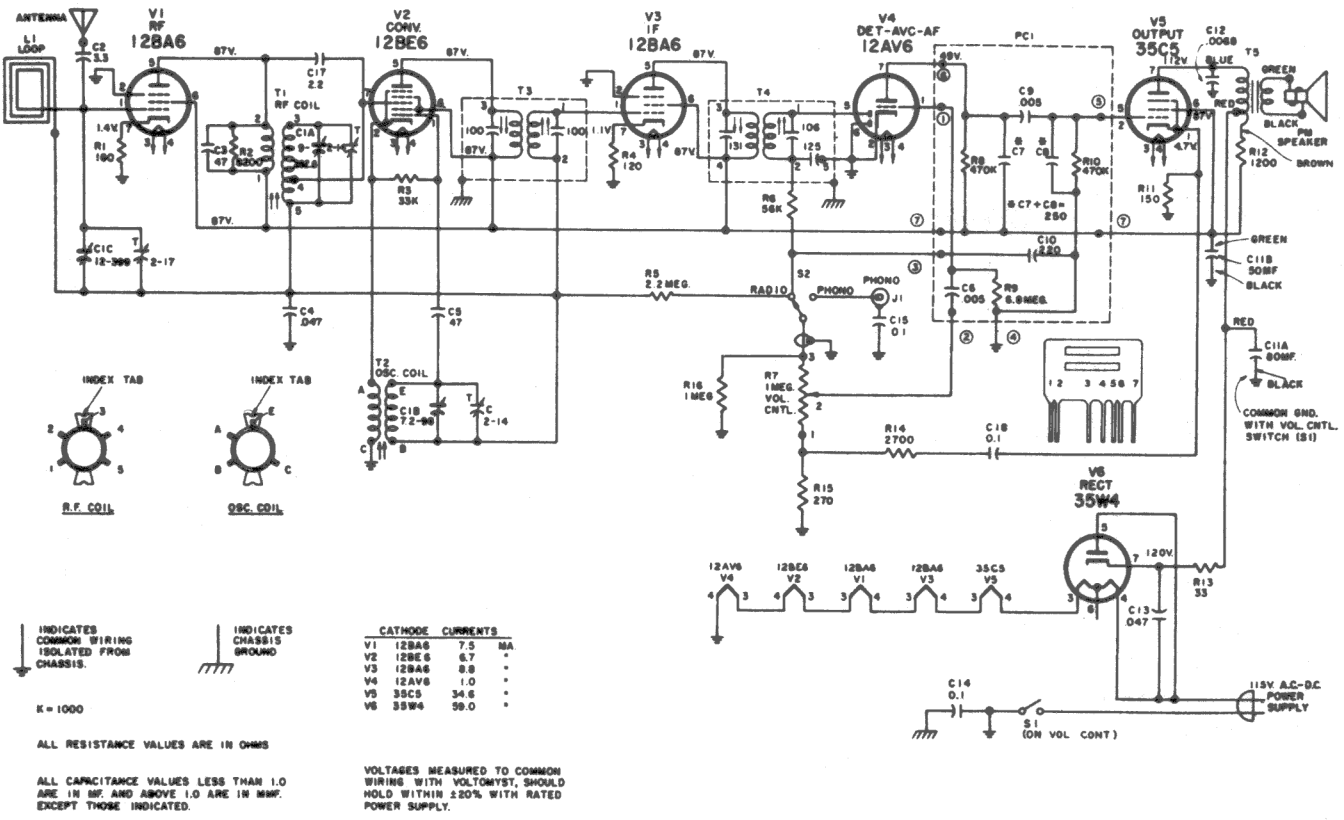


Fig. 18-11

the drawing C_{13} is connected from B MINUS to chassis. The ground symbol represents chassis.

Fig. 18-11 shows another way of drawing a schematic of an a.c.–d.c. radio. This is the schematic of the receiver shown in Fig. 18-1. On this diagram, the ground symbol does not mean a connection to chassis. Instead, it means a connection to the common wiring. The ground symbol in Fig. 18-11 is the same as the heavy line in Fig. 18-10. A different symbol is used for chassis ground in Fig. 18-11. The symbols used in Fig. 18-11 are explained in the lower left-hand corner of the schematic. In general, when ground symbols are used in an unusual way, they are explained on the diagram. At the present time, most a.c.–d.c. receiver schematic diagrams follow one of the two systems illustrated in Fig. 18-10 and 11.

18-4. CIRCUIT TRACING

We do not trace the entire circuit of a receiver all at once, but one section at a time. There are a number of ways to divide a radio circuit into sections. The best way to use in a particular case depends upon the purpose we have for circuit tracing.

Circuit tracing is done for various reasons. The first time we service a radio model, we begin by finding out how it is put together. We find this out by circuit-tracing the radio. Another purpose would be to locate any defects in the wiring before we start to systematically troubleshoot. In this sense, circuit tracing is the first step in troubleshooting.

One way to divide the receiver circuit is according to the function of each section, the way a block diagram shows functions. So, if we know that a receiver has no audio output and the other circuits work correctly, we trace the audio circuit.

We can also divide a radio circuit into smaller sections that nevertheless are complete circuits. The main circuits of a re-

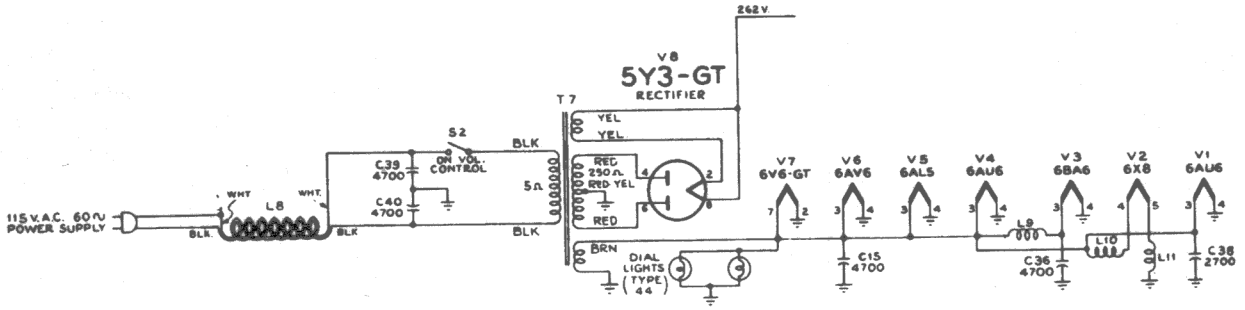


Fig. 18-12

ceiver subdivided this way are:

Filament circuits

B supply circuits

Signal circuits

There are other small circuits within a receiver, too. For instance when fixed bias voltages are used, the bias circuit is electrically a complete circuit called the *C* supply circuit. Complete electric circuits of many types are found within the over-all circuits of electric equipment other than radio receivers. Subdividing a radio into the three circuits listed is particularly useful when circuit tracing to see how a new model is connected together. Also, it is useful when we suspect that the trouble is in one of the three sub-circuits. Let us see how these circuits appear on schematic diagrams. Fig. 18-11 shows a filament circuit in the lower right-hand corner of the schematic diagram. The filament connections are omitted at the tube symbols, and the complete filament circuit is drawn separately. In this set, the tube filaments are connected in series across the 115-volt power line. Figure 18-12 shows the filament circuit of an a-c operated receiver. Here most of the filaments are connected in parallel across a 6-volt winding of the power transformer. There is a second 5-volt filament winding on the power transformer for the 5Y3 rectifier tube. A separate winding is used for two reasons. First, because a source of 5 volts instead of 6 volts is needed. Second, because there is a +262 volt potential on the 5Y3 filament, and this point could not be connected to the chassis.

Another part of schematic diagrams is concerned only with showing how the high voltage, or *B*+ voltage, is distributed. Fig. 18-13*a* is a schematic diagram of the portable radio of Fig. 18-2. The *B*+ circuit of this set is shown in Fig. 18-13*b*. Each tube is connected in parallel with the *B* battery in the *B*+ circuit shown. There is a complete electric circuit from the negative terminal of the battery through R_{11} to ground and from ground through each tube back to the positive terminal of the battery. Note that fixed bias is applied to the output grid (pin 6). The *C* voltage is taken from the negative terminal of the *B* battery, which is at a negative potential with respect to ground.

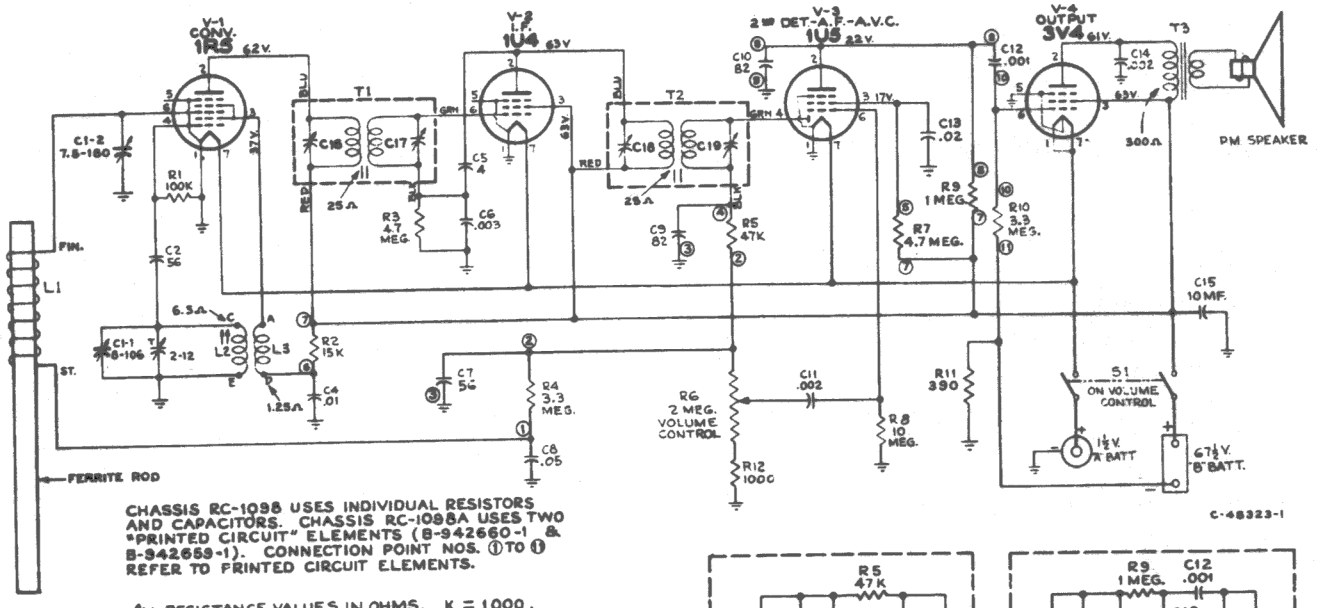
Most tubes in a radio need *B* supply voltage at the plates and screen grids to operate. However, diodes and rectifiers do not; in fact, it is one function of these tubes to change a.c. to d.c. Thus, the 5Y3 of Fig. 18-12 changes the a.c. that is applied to its plates to the d.c. that appears at its filament. The filament is at a potential of +262 volts d.c. The +262 volts is *B* supply voltage for the receiver using the power supply shown in Fig. 18-12.

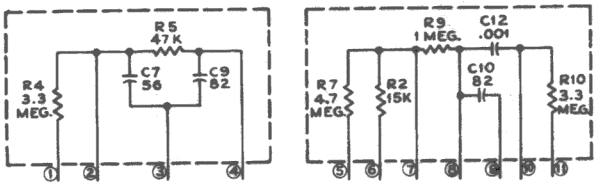
18-5. SIGNAL-CIRCUIT TRACING

The signal circuit differs from the filament and *B*-supply circuits in that the signal follows a different path or circuit. The signal is an a-c voltage, and the antenna is the the source of signal voltage as far as a receiver is concerned. The signal voltage is applied between the antenna and the chassis. It is as if the signal were made in a generator with one of its output terminals connected to the receiver's antenna terminal and the other output terminal connected to the chassis. The signal and *B*+ voltages exist to-

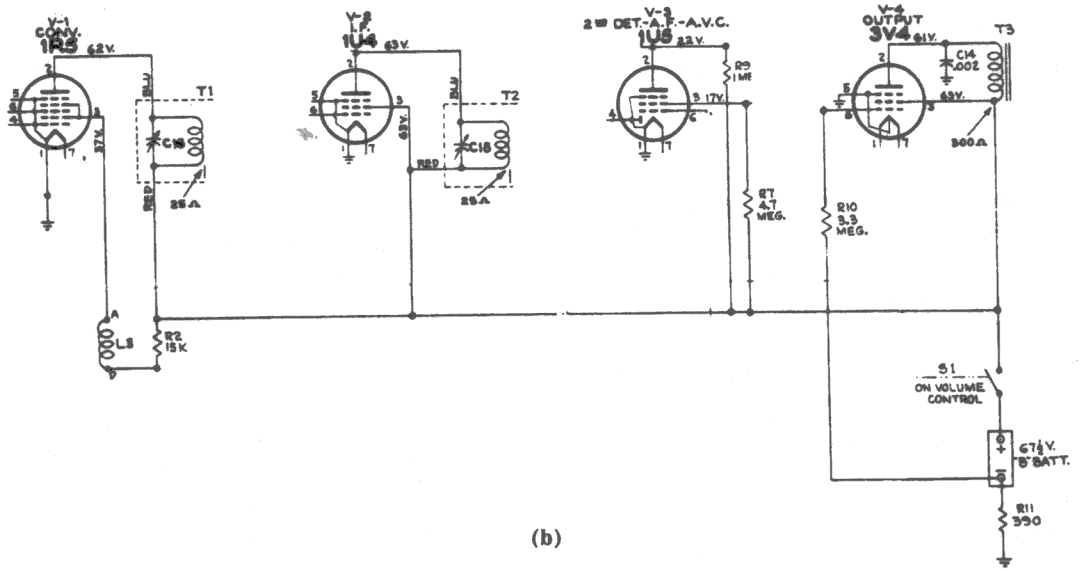
gether at many points within a receiver. Usually, the signal current has to follow a path different than the $B+$ current path. Let us read the schematic of Fig. 18-13 with a view to seeing how $B+$ current goes one way while signal current goes another way.

Look at T_2. There are signal current and $B+$ current in the primary winding of this transformer. We want the signal to be coupled to the diode plate (pin 4) of the 1U5 tube. We do not want $B+$ to be applied to the diode. The alternating signal current induces a signal voltage in the secondary winding of T_2. This signal voltage is applied to the diode. The d-c $B+$ current cannot induce a voltage in the secondary of T_2. We say that *transformers can be used to block d-c but pass a-c signals. Capacitors* have the same quality. They *block d-c but pass a-c signals.*





(a)



(b)

Fig. 18-13

Capacitors are used for this purpose in two ways: as coupling capacitors and as bypass capacitors. C_{12} of Fig. 18-13 is a coupling capacitor. It couples the signal from the plate of 1U5 tube to the grid of the 3V4 tube and prevents $B+$ from being applied to the grid of the 3V4. C_4 is a bypass capacitor. It connects terminal D of L_3 to chassis for signal current but not for $B+$ current.

Since we know that capacitors and transformers pass a-c signals but block d-c voltages, we can trace the signal path through the entire radio circuit of Fig. 18-13.

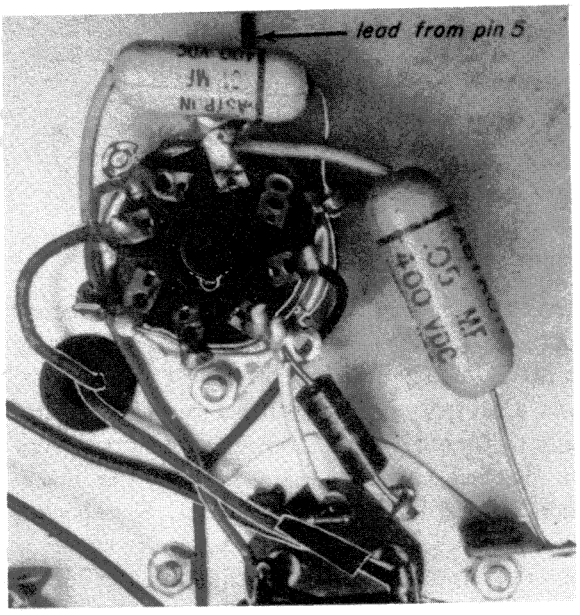
18-6. POINT-TO-POINT CIRCUIT TRACING

Let's suppose we wish to trace the $B+$ circuit of the receiver shown in Fig. 18-3*a*. We start with the positive terminal of the battery, which is easy to locate on the radio chassis and also easy to locate on the wiring diagram of Fig. 18-3*b*. Since the wiring diagram is simpler than the schematic, we will use it as much as possible. When we need more information than the wiring diagram can provide, we will turn to the schematic diagram of Fig. 18-13*a*. For instance, we trace the $B+$ wiring from the positive terminal of the battery to the on-off switch, but we must turn to the schematic to find out from which of the four terminals of the switch does the $B+$ wiring continue. The schematic diagram tells us the wire goes directly from the switch to pin 3 of the 3V4 tube. By directly, we mean that $B+$ current does not have to pass through a coil or resistor to get to pin 3, and not that it goes through a continuous wire unbroken by connections at tie lugs. We can find which terminal of the switch is $B+$ by tracing back from a point we know to be $B+$.

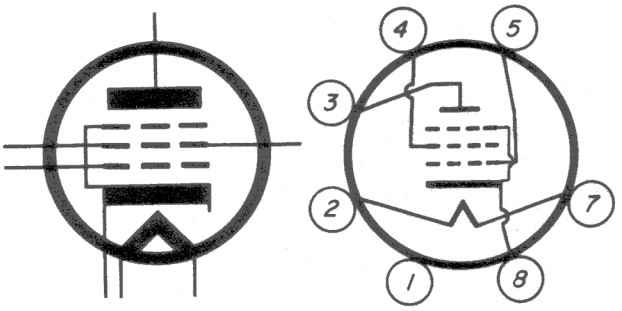
Note that we are tracing from point to point through the circuit in a direction opposite to the direction in which electron current flows through the circuit. It is not necessary to trace a circuit in the same direction that current flows.

The wiring diagrams show a lead going from pin 3 of the 1U4 tube to a lead labeled $B+$. This confirms that we are on the right path. One lead from the $B+$ terminal goes to the switch. Thus, we have located the unknown $B+$ terminal of the switch. Let us continue tracing toward the 1R5 tube. There are four leads connected at the $B+$ terminal. We already know where two of the leads go. A third goes to the output transformer. The fourth is a lead to R_2. The other end of R_2 is connected to terminal D of the oscillator coil. Checking the schematic, we see that this path will lead to pin 3 of the 1R5 and that the $B+$ circuit continues from terminal A of the coil. Looking at the wiring diagram, we see that terminal A is connected directly to pin 3 of the 1R5. Note that pins 3 and 4 of the 1U4 tube, both at $B+$ potential, supply $B+$ to pins 2 and 3 of the 1U5 tube through resistors R_9 and R_7, respectively. Also pin 4 of the 1U4 tube supplies $B+$ to pin 3 of the 3V4 tube. Now we continue to the negative terminal of the battery. The schematic shows that the $B+$ circuit reaches ground by way of pin 1 of the 1R5. The wiring diagram confirms that pin 1 is connected to chassis. Again, we consult the schematic. Now, how do we return to the negative side of the battery? Examination of the schematic shows that, electrically, the path from chassis to the battery is through R_{11}. Where is R_{11}? It is connected to pin 4 of the 3V4 tube and to chassis. How do we know? We use the wiring diagram to trace the wire from the negative terminal of the battery back to pin 4 of the 3V4. Here, we see R_{11}.

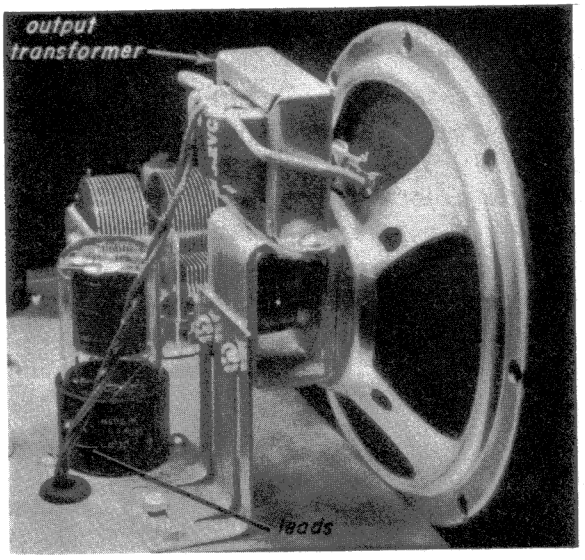
We have traced the circuit point to point. To do so, we have used schematic and wiring diagrams. Let us see what can be done without diagrams. Fig. 18-14*a* is a photo of the socket wiring of an audio-output tube. We are going to trace this circuit, and, as we do so, we will draw the schematic. To begin, we draw a pentode tube symbol, as in Fig. 18-14*b*. We know the tube is a 6K6-GT, so we can find the pin numbers of the various elements by using the RCA Tube Manual. Figure 18-14*c* shows the 6K6-GT tube symbol as it appears in the tube manual. Now, we draw the wires and parts connected to the socket, starting with pin 1. As you know, pin 1 is the first pin on the clockwise side of the tube key. Pin 1 is marked NC, which means no connections. Pin 2 goes to one side of the heater. By looking at the socket wiring, we find that pin 2 is connected to the chassis. We show this



(a)



(b) (c)



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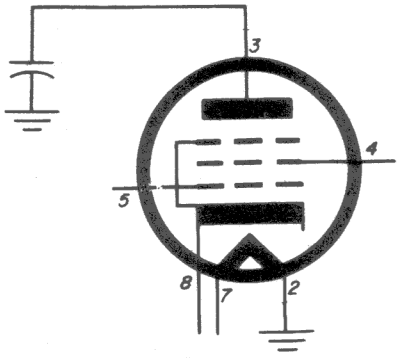

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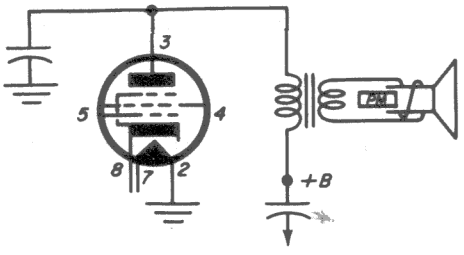

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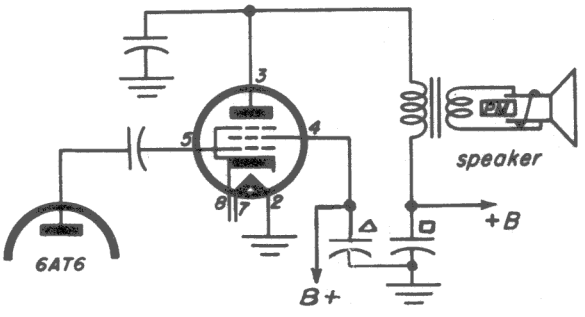
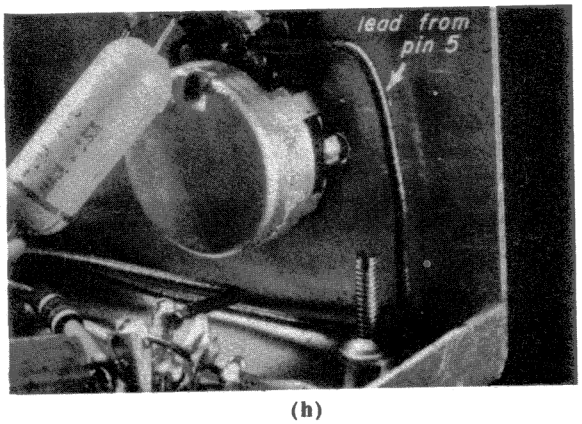
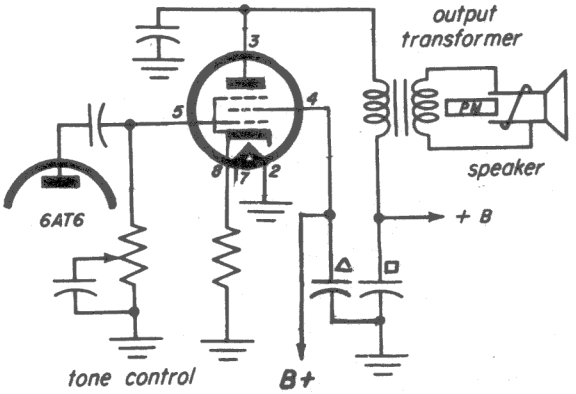


(g)



(h)



(i)

Fig. 18-14

on our schematic as in Fig. 18-14*d*. Pin 3 has two wires connected to it. One is a capacitor lead. The other lead of the capacitor is connected to chassis. We add the capacitor to our schematic. The second lead goes through a hole in the chassis out of sight. We have to turn the chassis over to see where it goes. Fig. 18-14*e* is a photo of the other side of the chassis. The lead goes to the output transformer. Another lead from the transformer returns to the underside of the chassis. It connects to the terminal of an electrolytic capacitor. We can draw the addition to our schematic as in Fig. 18-14*f*. The secondary of the output transformer goes to the speaker voice coil. We draw this, too. The electrolytic tie point as a $B+$ on our schematic. Consider the other terminal of the electrolytic? Where does *it* connect? The other terminal of the electrolytic is its case which is connected to chassis. We draw this as in Fig. 18-14*g*. Figure 18-14*g* also shows pin 4 of the 6K6-GT connected to $B+$ and the electrolytic capacitor. A coupling capacitor is connected to pin 5. We know this because its other lead goes to the plate of the audio amplifier, pin 7 of the 6AT6. There is no connection to pin 6 of the 6K6-GT. To trace the remaining lead from pin 5, we have to look at the chassis from a different angle. The needed view is shown in Fig. 18-14*h*. The lead goes to the tone control. The center arm of the tone control is connected to ground through a capacitor, and the remaining end terminal is connected directly to ground. These additions to our schematic are shown in Fig. 18-14*i*. Also shown are the filament connections at pin 7 of the 6K6-GT and the resistor to ground from pin 8. This is the audio-output stage of the receiver that you are building as part of this course.

A tube socket is always a good starting point for circuit tracing. But we do not always draw a schematic when we circuit-trace without diagrams. With experience, you will recognize circuits after checking a few of the connections. However, it is desirable to trace a circuit as carefully as though you were actually drawing a schematic.

While a tube socket is a good starting place it is not the only place to start tracing a circuit. Any radio part that you recognize

Special Code for Electrolytic Capacitors having leads instead of terminals.

Orange	Highest voltage section
Red	Next highest voltage section
Blue	Next to lowest voltage section
Yellow	Lowest voltage section
Black	Common negative connection

Fig. 18-15

can serve to identify a circuit. Resistors look alike, but they can be identified by the color code. This is true of small capacitors, too. Electrolytic capacitors are large and easy to locate. The terminals of electrolytics are marked, and the meanings of the markings are explained on the label. Sometimes, electrolytics have colored leads instead of marked terminals. The meaning of the colors is usually explained on the label of the electrolytic capacitor. The table of standards of Fig. 18-15 will serve as a guide. Other wiring color standards have been explained in other lessons.

Caution: Some schematics and service-data booklets provide information on how leads should be placed in the wiring. When circuit tracing, be careful not to disturb the correct placement of these wires. A listing of critical lead dress for the portable radio shown in Fig. 18-13 is given in Fig. 18-16. The leads listed may not be critical in all receivers. However, by dressing them as specified, unusual difficulties will be avoided.

18-7. VISUAL INSPECTION FOR WIRING DEFECTS

As we trace a circuit, we are careful not to disturb critical lead dress. So, why not go

CRITICAL LEAD DRESS

1. Dress all I-F transformer leads down to base and push any excess lead back in can.
2. Black lead from 1st I-F should lay down against top of tube shelf with capacitor C6 over it.
3. Dress neutralizing capacitor C5 direct and above chassis base, avoid lead length.
4. Dress blue lead from volume control and green lead from terminal board near volume control down to base and under gang frame diagonally to termination.
5. Dress blue lead from output transformer under clamp on back of gang condenser and direct to terminal 2 of V4.
6. Adjust Ferrite antenna so that coil end of rod extends two inches beyond tube shelf.
7. Dress all bare wires, pigtail leads and non-insulated components to prevent shorts.

Fig. 18-16

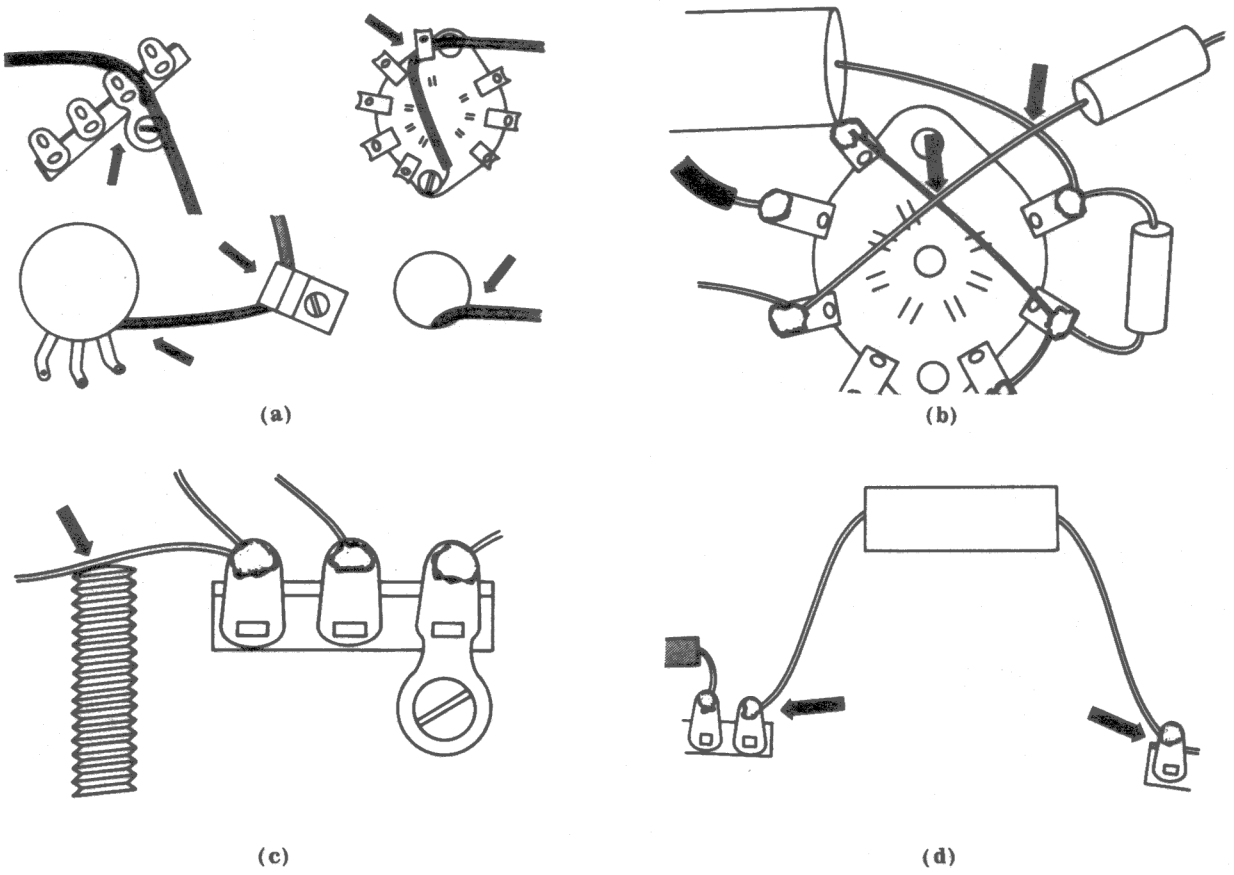


Fig. 18-17

a step further and correct improper lead dress? Our attention is focused upon the wiring when we trace a circuit. We can accomplish two things at once by making a visual inspection for wiring defects while we circuit trace. Wires need not be critical to be incorrectly placed. For example, wires should not be drawn tight around sharp edges of the chassis or terminal connections (Fig. 18-17*a*).

Uninsulated leads should be dressed away from each other to avoid contact between them. They should not be dressed as shown in Fig. 18-17*b*. Be sure that uninsulated leads are not in a position to be contacted by mounting bolts, as in Fig. 18-17*c*. You may overlook this possibility because you have the chassis out of its cabinet. The bolt is not in place. Capacitor leads should not be too long. There is a danger that they may bend out of position and contact other uninsulated leads. Also, when heavy capacitors are supported by long, thin leads, as shown in Fig. 18-17*d*, the weight of the capacitor may cause the leads to break. This could happen while the set is being transported.

So far, we have been discussing incorrect wiring that has not yet caused trouble. A visual inspection can also detect chassis wiring defects that are causing trouble. It is wise to determine whether or not such trouble is the customer's complaint *before* you remove the defect. Otherwise, if the set works properly, you may have difficulty deciding whether or not there is anything else wrong.

Wiring defects are mainly of two types. The first is accidental contact between a wire and chassis, and the second is faulty connections causing poor electrical contact. The first type of wiring defect is called a short circuit. Figure 18-18 illustrates some examples of short circuits in chassis wiring. At *a*, a lump of solder has fallen against a terminal lug, shorting the lug to chassis. At *b*, a scrap of wire is shorting a lug to chassis, this time by

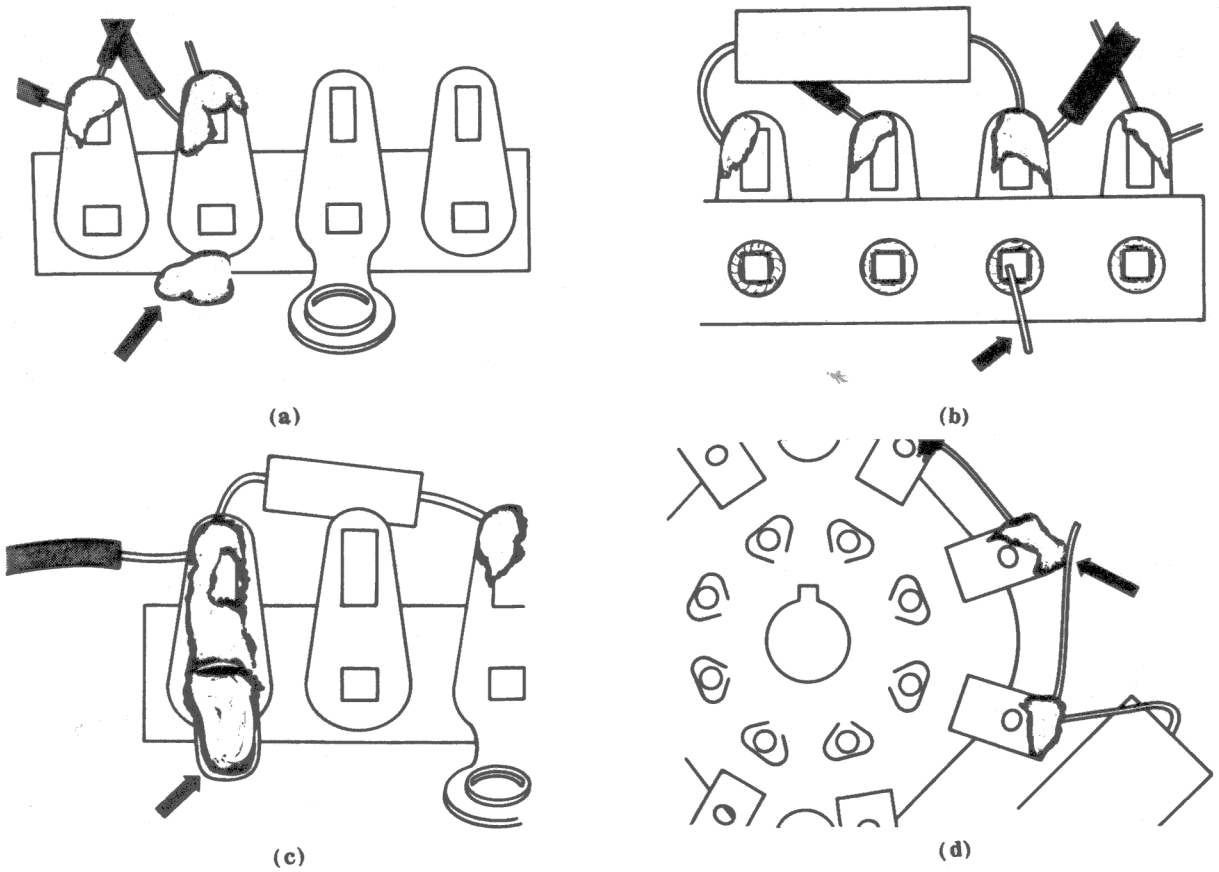


Fig. 18-18

means of the rivet like lug mounting. At *c*, a ball of excess solder rolling around on the chassis is shorting a terminal lug to the chassis. At *d*, one strand of stranded wire is touching the next terminal. Poor electrical contact between wires results from unsoldered and poorly soldered connections.

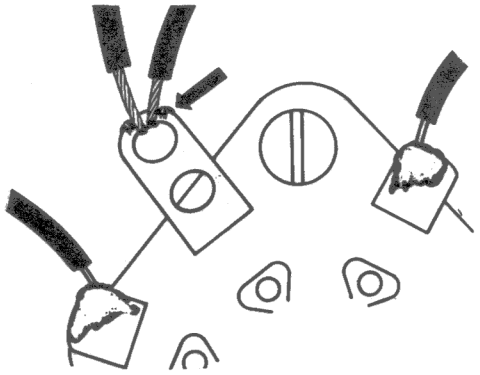
Figure 18-19*a* shows an unsoldered connection. At *b*, two leads are soldered to a lug while a third is connected but not soldered. In *c*, a wire passing through a lug is not wrapped around it; as a result, a rosin connection causes poor contact. An unusual kind of unsoldered connection is shown at *d*. The wire inside a tube pin is not soldered to the pin.

18-8. CONTINUITY TESTING

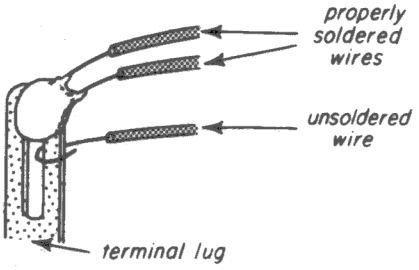
Layout, wiring, and schematic diagrams inform us how a circuit *should* be connected together. When circuit tracing, we find out whether or not the circuit *is* connected as it should be. We do so by visually inspecting the wiring. Another means of checking connections is called continuity testing. It is used when we cannot actually see a connection but we know from our diagrams that the connection should be present. A switch is an example. We know two terminals of a switch should be connected together when the switch is turned on. But, how can we be sure this actually happens? We can check with an ohmmeter. The meter will show zero ohms across the terminals if contact is made when the switch is turned on. When we do this, we are making a continuity test. We are finding out if the path for current flow through the switch is continuous.

Use of the Ohmmeter. We use an ohmmeter while circuit tracing to continuity-test connections we cannot check visually. It is especially useful for checking many-wire cables, such as the one illustrated in Fig. 18-20. We could inspect the connections visually. Plugs can be taken apart. But it is easier to use an ohmmeter. Small lengths of wire, like those in receiver cables, have

practically no resistance. If there is continuity between two ends of these wires, the meter shows zero ohms. With no continuity



(a)



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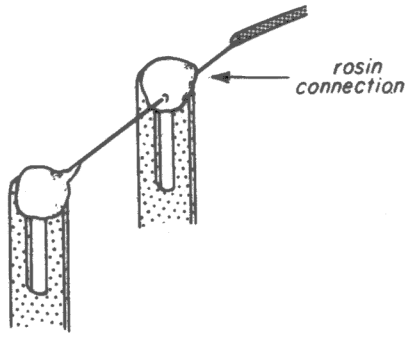

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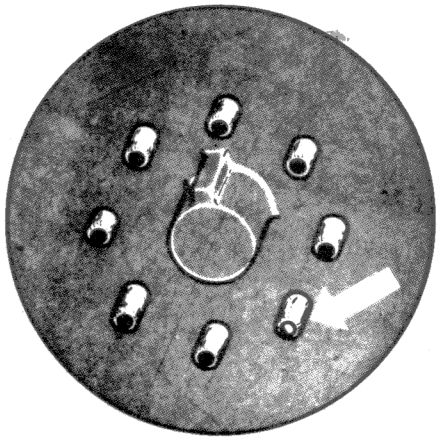


(d)

Fig. 18-19

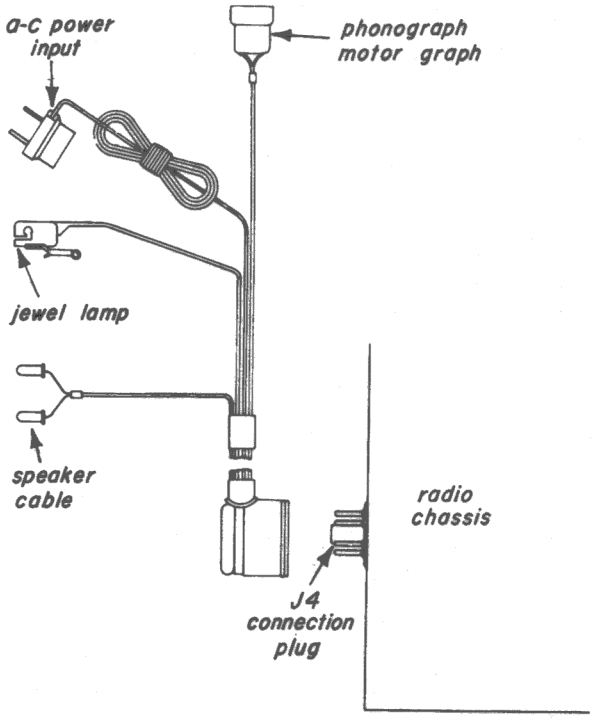


Fig. 18-20

(opened connection), the meter shows infinite (∞) ohms. We are mainly interested in whether the meter pointer moves or does not move when checking wiring for continuity. However, it is necessary to check on all scales of the meter. This is simply a matter of rotating the meter selector switch from the R x 1 to the R x 100 to the R x 10K position each time that we check continuity. Let us see how we could make a mistake if we did not rotate the switch. Assume we are checking between two terminals that should have no connection. Actually, there is a poor connection. Instead of there being zero ohms, the connection has a resistance of 5,000 ohms. We do not know this. Now, we check with the meter. We have it on the R x 1 position. A glance at the meter ohms scale of Fig. 18-21 confirms that the meter will show infinite ohms, meaning no connection. We are deceived, unless we rotate the

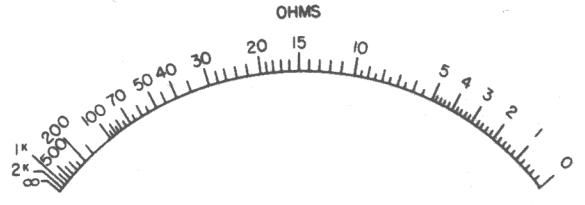


Fig. 18-21

selector switch. If we select the R x 10K position, we will surely find the unwanted connection. The meter pointer will come to rest at a position between 0 and 1 on the scale.

By now, you may have guessed that we have to study troubleshooting somewhat when we study circuit tracing. Visual inspection and continuity testing are the first parts of troubleshooting. The troubleshooting that can be done without applying power to the receiver is troubleshooting with an ohmmeter.

Caution: Be sure that power is not applied to the receiver before measuring with an ohmmeter. The meter can be damaged if you measure resistance in a set with power on. Also, take time to discharge the power-supply filter capacitors before measuring with an ohmmeter. These capacitors charge to the B+ potential. In circuits with no power-supply bleeder, it may take a long time for the charge to leak off. In circuits that do have a bleeder, a bleeder resistor may be opened. Here, too, the charge may leak off slowly.

Now, let us consider some other uses for an ohmmeter where we look for more than just zero and infinite readings. Of course, it is a simple matter to measure the resistance of a part when it is not wired into a circuit. When it *is* in a circuit, we have to consider how the rest of the circuit will affect the meter reading. Resistors and other radio parts in a circuit frequently have resistances in parallel across their terminals. This reduces the ohmmeter reading across these terminals. When the parallel resistance is large compared to what we want to measure, the reading is not reduced much. When the parallel resistance is small, we get a very low reading. As an example, refer to Fig. 18-22; it shows a 10-ohm coil in parallel with a 5,000-ohm resistor and a 33-$\mu\mu$f capacitor. What will we measure across the terminals? For practical purposes, we can expect to measure 10 ohms the resistance of the coil. The capacitor has almost infinite resistance, and the resistor has so much more resistance than the coil that it

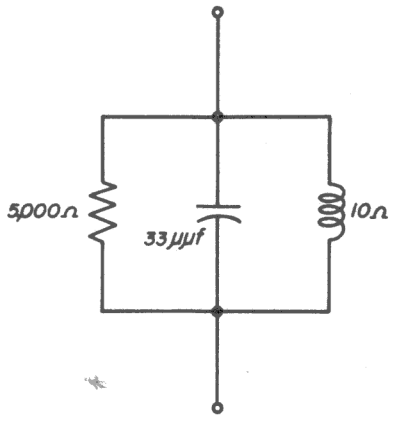


Fig. 18-22

cannot reduce the total reading by much. We can check this with the following formula:

$$R_t = \frac{R_1 \times R_2}{R_1 + R_2}$$

$$= \frac{50{,}000}{5{,}010}$$

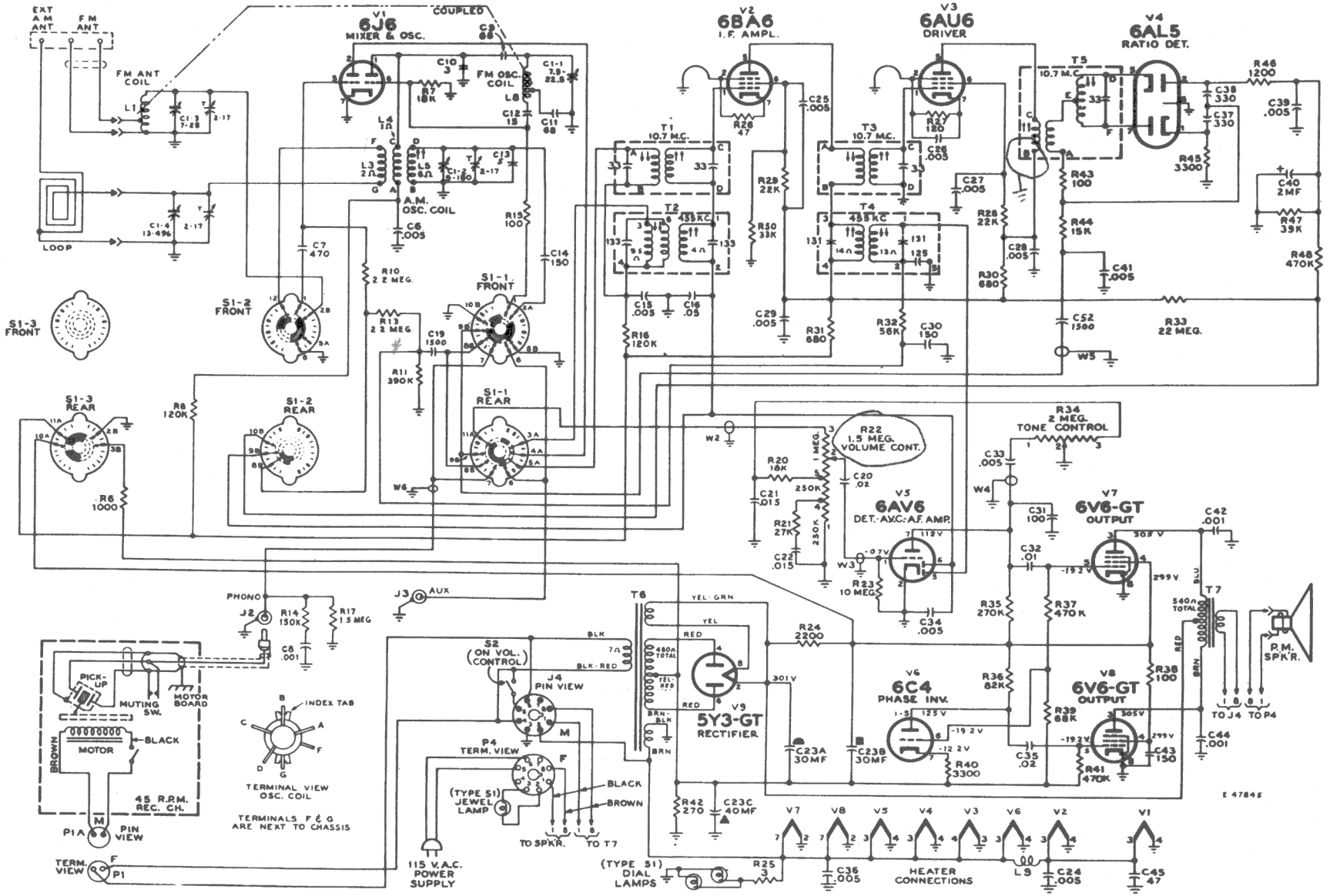
$$= 9.9 \text{ ohms}$$

If it is the resistance of the resistor that we want to measure, we will have to remove one end of it from the circuit. It is necessary only to remove one end of the resistor to electrically disconnect it from the circuit. Whenever this is done, be careful not to damage any parts or connections. After measurement, the part should be carefully soldered back in place. An interesting point to notice is this. If we measure across the terminals of this circuit with an ohmmeter and read 5,000-ohms, we know immediately that there is an open connection at the coil or that the coil wire is broken.

While schematics often indicate the resistance of coils, do not expect them to be accurate. Since the inductance of the coil, and not the resistance, is important for proper operation of the circuit, the manufacturer is more careful to keep the inductance indications exact.

When making resistance measurements, it is necessary to locate parallel resistance. This we do by circuit tracing. We can use the schematic of Fig. 18-23 to illustrate this.

The cathode neutralizing loops of V2 (6BA6) and V3 (6AU6) are insulated wires approx. 2 in. long. Do not alter length.



FUNCTION SWITCH VIEWED FROM FRONT AND SHOWN IN "AUX" POSITION (MAX. COUNTERCLOCKWISE).
VOLTAGES MEASURED TO CHASSIS WITH VOLTOHMYST AND NO SIGNAL INPUT AND SHOULD HOLD WITHIN ±10% WITH 117 VOLT POWER SUPPLY.
CAPACITOR VALUES LESS THAN 1 ARE IN MF., VALUES GREATER THAN 1 ARE IN MMF. UNLESS OTHERWISE SPECIFIED. RESISTANCE VALUES IN OHMS. K = 1000.

Fig. 18-23

It is the most complicated schematic studied in this lesson, and will provide the final circuit tracing exercise. Suppose we want to measure resistance from a $B+$ terminal to the chassis. We choose terminal B of T_5. What should we read on the meter? From terminal B to ground, there are three resistors in series. These are R_{30}, R_{29}, and R_{50}. The total resistance is the sum of these: 680 ohms +22,000 ohms +33,000 ohms. We should read approximately 55,680 ohms. R_{33}, R_{48}, and R_{47} are in parallel with R_{29} and R_{50} but are too large to affect the reading. We can measure the series combination of R_{30}, R_{29}, and R_{50}. However, we can not accurately measure R_{33}. To understand why, find the resistance in parallel with R_{33}. Trace the circuit as follows: From R_{33} to R_{48} to R_{47} to ground. Then from ground to R_{50} to R_{29} back to the opposite side of R_{33}. Totaling the resistance in parallel with R_{33}, we add 470,000 ohms, 39,000-ohms, 33,000 ohms, and 22,000 ohms. We have 564,000 ohms in parallel with R_{33}, which is 22,000,000 ohms. We would read approximately 564,000 ohms.

Suppose, when we measured from terminal B of T_5 to ground, that instead of reading 55,680 ohms (as we should), we read 680 ohms. We suspect that there is an accidental connection to chassis at the junction of R_{29} and R_{30} so that the total resistance to ground is the resistance of R_{30} alone (680 ohms) instead of R_{30} +R_{29} +R_{50}. To confirm our suspicion, we measure from the junction of R_{29} and R_{30} to ground. If the meter reads zero, we know we are right. We then find the cause of the unwanted connection and correct it.

Let us take another example from the schematic of Fig. 18-23. We want to measure the resistance of the volume control, R_{22}, from terminal 5 of the control to ground. R_{21} is not in parallel, because C_{22} blocks the path. C_{20} blocks the path from terminal 2. There is no path to ground from terminal 3. From terminal 5, we go to an 18 k-ohm resistor, the other end of which goes to a 2-megohm resistor. Both resistors are in parallel with 500 k-ohms of the volume control; the total resistance is 0.4 megohm. But when the tone-control center arm is set at its terminal 3, only R_{20} (18 k-ohms) is in parallel with the 0.5-megohm portion of the volume control. The total resistance from terminal 5 of the volume control to ground is 18 k-ohms. So, with our ohmmeter connected between terminal 5 of the volume control and ground, we can change the reading from 18,000-ohms to 400,000-ohms by turning the *tone-control shaft*. Turning the volume-control shaft will not change the reading.

The final example: Suppose we want to check continuity through the 6-volt filament winding. Can we simply measure from ground to the BRN lead? No, because we would be reading through the tube filaments. This applies also to checking the continuity of a tube filament. It is necessary to remove the tube from its socket to avoid reading through the other tube filaments.